Short communication

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Gran-size and chironomid analyses of the upper sediment core of Lake Usvyatskoye (Pskov region, Russia)

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ABSTRACT. Grain size and chironomid analyses of the upper core of the Usvyatskoye Lake (Pskov area) were carried out. The estimated age of the core covers the last 2000 years. Preliminary results of grain-size analysis identified four facies in the studied core. Analysis of chironomid taxonomic composition showed a change in dominant taxa, that is correlated with changes in grain size.

Keywords: Paleolimnology, lake bottom sediments, grain-size analysis, chironomid analysis, The trade route from the Varangians to the Greeks, Lake Usvyatskoye, North-Western Russia.

1. Introduction

The main aim of our research is to perform paleoclimatic and paleoenvironmental reconstruction of the watershed area of the Western Dvina, Lovat and Dnieper rivers. Assumedly "The trade route from the Varangians to the Greeks" passed here in the 11-12th century (Grekov et al., 2022). Paleolimnological investigation of this area may help to understand the natural and human history of the territory during this period.

2. Materials and methods

The object of our research is the Usvyatskoye Lake (55.72N, 30.79 E), which belongs to the basin of the Western Dvina River, Pskov region. The lake is located on a large watershed section of "The trade route from the Varangians to the Greeks", in the Usvyacha river's course.

For a short core from Lake Usvyatskoe (estimated age 2000 years), grain-size and chironomid analyses were carried out.

The results of grain-size analysis are used to determine the nature of changes in the granulometric composition of sediments, to establish the nature of hydrological and water level regimes of the lake in the past (Karevskaya and Panina, 2012). Organic elements were removed from the samples using a 37% hydrogen peroxide solution and distilled water in a 1:1 ratio. The grain-size analysis of the samples was carried out in the Laboratory of Paleolimnology of the Herzen University using the laser particle analyser LASKA. During sample preparation, the sediment core was divided with 1 cm resolution.

Sample treatment for the chironomid analysis was performed followed standard technique (Brooks et al., 2007). Samples for chironomid analysis were taken from the upper part of the column from 1.20 to 1.85 m. Chironomids were identified with reference to Wiederholm (1983) and Brooks et al. (2007). The biodiversity and evenness of chironomid communities were assessed using Shannon's indices (H) (Shannon and Weaver, 1963) and Pielou's indices (I) (Pielou, 1966)

3. Results and discussion

3.1 Grain-size analysis

The core is dominated by fractions of physical clay – silt (fine and coarse), fine and medium dust, as well as coarse dust belonging to the fraction of physical sand.

Facies boundaries are drawn along the depths at which sharp changes in the size of mineral particles are noted and which separate core gaps of similar particle sizes from each other.

The first (1.16-1.36), third (1.56-1.82) and fourth (1.82-2) facies are characterized by the predominance of physical clay and slightly smaller average particle sizes than in the second facies.

In the second facies (1.36-1.56), an increase in the proportion of coarse dust (10-50 microns), which belongs to the fraction of physical sand, is clearly traced. The maximum content of large particles falls on the sample from a depth of 1.35-1.36 meters. The increase in the size of mineral particles probably indicates an increase in the speed of the Usvyacha River. This peak may be related to the vigorous all agricultural activity

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in the region in the 20th century. This peak may be related to the vigorous all agricultural activity in the region in the 20th century.

3.2 Chironomid analysis

Identified chironomid head capsules belong to **52** taxa. The analysed taxa belong to 3 subfamilies: *Chironominae, Orthocladiinae, Tanypodinae*. According to the results of cluster analysis, three statistically significant zones were identified in the studied column of sediments.

In the lower part of the core (1.70-1.84 m), the Shannon and Piellow index values are low, along with the total number of taxa. This may be due to a certain cooling of the climate during this period. Subsequently, biodiversity and evenness of communities increase. This may indicate warm climatic conditions and high-water levels in the reservoir. There are profundal species of chironomid, which indicates a high-water level. In the range from 1.39 to 1.58 m, the reconstructed conditions of this period are characterized by the appearance of cold-water stenothermal taxa, which may indicate some cooling of the climate. The Shannon and Piellow index values drop to H ~ 2.3 - 2.5 and I ~ 0.37 - 0.55, respectively. In the upper part of the core (1.39 – 1.20 m), we observe a change in the dominant taxa: in this area, the number of *Pseudochironomus* acidophilus and *Dicrotendipes nervosus*-type increases. This indicates some eutrophication of the lake. The occurrence of cold-water stenothermic taxa may indicate some cooling of the climate. The zones described above characterize the studied core as a change in warm and cold climatic conditions in the entire core. Water level fluctuations in the lake are also recorded.

4. Conclusions

The relationship between particle size distribution and chironomid analysis can be clearly seen. The last zone (1.20 - 1.39 m) can be attributed to the last 100-200 years. The predominance of the clay fraction characterizes the slow movement of water in the lake and the increase in its level, which is reflected in the nature of the species living in the lake. Sharp fluctuations in graphs with anomalies can fix active anthropogenic activity in the watershed. For a long time before this, the period of cold natural conditions (1.39-1.56 m) is characterized by the highest values of the sand fraction in the bottom sediments of the reservoir throughout this core. This indicates a more intense runoff of the Usvyacha River and other watercourses flowing through Lake Usvyatskoe. Below this, a warm zone is fixed (1.56-1.72 m) characterized by a large number of the smallest fractions in granulometry and profundal chironomid species, which indicates that the water level at that time was noticeably higher than the current one. Before this period, cold-water conditions are observed again.

This alternation of warm and cold periods with very different natural conditions corresponds to the last 1200 years of history (Arslanov et al., 2020; Nirgi et al., 2021). Based on this assumption, it can be said that the cold long period belongs to the Medieval Little Ice Age, and noticeable warm conditions correspond to the Medieval Climatic Optimum (approximately 900-1350 AD). It was at this time that there were the most full-flowing and hottest conditions in the history of the lake over the past 1200 years.

Preliminary results of grain-size analysis and chironomid analysis of bottom sediments of Lake Usvyatskoye show a clear change in sedimentation processes in horizons 136 – 148 cm (~ 1950-1300 yrs.). These data suggest a change in natural and climatic conditions during the study period.

In order to clarify results and perform quantitative reconstruction, it is planned to supplement with data from pollen and geochemical analysis, as well as radiocarbon dating.

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Conflict of interest

The authors declare that there is no conflict of interest.

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